CHAPTER 1

GENERAL

1-1. Purpose and scope. This manual presents criteria and procedures for the design and construction of pavements placed on subgrade or base course materials subject to seasonal frost action. The criteria are applicable to Army airfields and heliports and to roads for mobilization construction. The most prevalent modes of distress in pavements and their causes are listed in table 1-1. The principal modes unique to frost areas, with which this manual is concerned, are the non-traffic-associated distress modes of distortion caused by frost heave and reconsolidation, and of cracking caused by low temperatures, and the traffic-load-associated distress modes of cracking and distortion as affected by the extreme seasonal changes in supporting capacity of subgrades and bases that may take place in frost areas.

1-2. Definitions. The following frost terms are used in this manual.

a. Frost, soil, and pavement terms.

(1) Base or subbase course. All granular unbound, or chemical- or bituminous-stabilized material between the pavement surfacing layer and the untreated, or chemical- or bituminous-stabilized subgrade.

(2) Bound base. A chemical- or bituminous-stabilized soil used in the base and subbase course, consisting of a mixture of mineral aggregates and/or soil with one or more commercial stabilizing additives. Bound base is characterized by a significant increase in compressive strength of the stabilized soil compared with the untreated soil. In frost areas, bound base usually is placed directly beneath the pavement surfacing layer where its high strength and low deformability make possible a reduction in the required thickness of the pavement surfacing layer or the total thickness of pavement and base, or both. If the stabilizing additive is portland cement, lime or lime-cement-fly ash (LCF), the term bound base is applicable in this manual only if the mixture meets the requirements for cement-stabilized, lime-stabilized, or LCF-stabilized soil set forth in EM 1110-3-137 and in this manual.

(3) Boulder heave. The progressive upward migration of a large stone present within the frost zone in a frost-susceptible subgrade or base course. This is caused by adhesion of the stone to the frozen soil surrounding it while the frozen soil is undergoing frost heave; the stone will be kept from an equal, subsequent subsidence by soil that will have tumbled into the cavity formed beneath the stone. Boulders heaved toward the surface cause extreme pavement roughness and may eventually break through the surface, necessitating repair or reconstruction.

Table 1-1. Modes of distress in pavements.

Distress mode	General cause	Specific causative factor
Cracking	Traffic-load-associated	Repeated loading (fatigue) Slippage (resulting from braking stresses)
	Non-traffic-associated	Thermal changes Moisture changes
		Shrinkage of underlying materials (reflection cracking, which may also be accelerated by traffic loading)
Distortion (may also lead to cracking)	Traffic-load-associated	Rutting, or pumping and faulting (from repetitive loading)
		Plastic flow or creep (from single or comparatively few excessive loads)
	Non-traffic-associated	Differential heave Swelling of expansive clays in subgrade Frost action in subgrades or bases
		Differential settlement Permanent, from long-term consolidation in subgrade Transient, from reconsolidation after heave (may be accelerated by traffic)
		Curling of rigid slabs, from moisture and temperature differentials
Disintegration	May be advanced stage of cracking mode of distress or may result from detrimental effects of certain materials contained within the layered system or from abrasion by traffic. May also be triggered by freeze-thaw effects.	

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(4) Cumulative damage. The process by which each application of traffic load, or each cycle of climatic change, produces a certain irreversible damage to the pavement. When this is added to previous damage, the pavement deteriorates continuously under successive load applications or climatic cycles.

(5) Frost action. A general term for freezing and thawing of moisture in materials and the resultant effects on these materials and on structures of which they are a part, or with which they are in contact.

(6) Frost boil. The breaking of a small section of a highway or airfield pavement under traffic with ejection of soft, semi-liquid subgrade soil. This is caused by the melting of the segregated ice formed by frost action. This type of failure is limited to pavements with extreme deficiencies of total thickness of pavement and base over frost-susceptible subgrades, or pavements having a highly frost-susceptible base course.

(7) Frost heave. The raising of a surface due to formation of ice in the underlying soil.

(8) Frost-melting period. An interval of the year when the ice in base, subbase, or subgrade materials is returning to a liquid state. It ends when all the ice in the ground has melted or when freezing is resumed. In some cases, there may be only one frost-melting period, beginning during the general rise of air temperatures in the spring, but one or more significant frost-melting intervals often occur during a winter season.

(9) Frost-susceptible soil. Soil in which significant detrimental ice segregation will occur when the requisite moisture and freezing conditions are present.

(10) Granular unbound base course. Base course containing no agents that impart higher cohesion by cementing action. Mixtures of granular soil with portland cement, lime, or fly ash, in which the chemical agents have merely altered certain properties of the soil such as plasticity and gradation without imparting significant strength increase, also are classified as granular unbound base. However, these must meet the requirements for cement-modified, lime-modified, or LCF-modified soil set forth in EM 1110-3-137 and in this manual.

(11) Ice segregation. The growth of ice as distinct lenses, layers, veins, and masses in soils, commonly but not always oriented normal to the direction of heat loss.

(12) Non-frost-susceptible materials. Cohesion less materials such as crushed rock, gravel, sand, slag, and cinders that do not experience significant detrimental ice segregation under normal

freezing conditions. Non-frost-susceptible materials also include cemented or otherwise stabilized materials that do not evidence detrimental ice segregation, loss of strength upon thawing, or freeze-thaw degradation.

(13) Pavement pumping. The ejection of water and soil through joints, cracks, and along edges of pavements caused by downward movements of sections of the pavement. This is actuated by the passage of heavy axle loads over the pavement after free water has accumulated beneath it.

(14) Period of weakening. An interval of the year that starts at the beginning of a frost-melting period and ends when the subgrade strength has returned to normal summer values, or when the subgrade has again become frozen.

b. Temperature terms.

(1) Average daily temperature. The average of the maximum and minimum temperatures for 1 day, or the average of several temperature readings taken at equal time intervals, generally hourly, during 1 day.

(2) Mean daily temperature. The mean of the average daily temperatures for a given day in each of several years.

(3) Degree-days. The Fahrenheit degree-days for any one day equal the difference between the average daily air temperature and 32 degrees F. The degree-days are minus when the average daily temperature is below 32 degrees F. (freezing degree-days) and plus when above (thawing degree-days). Figure 1-1 shows curves obtained by plotting cumulative degree-days against time.

(4) Freezing index. The number of degree-days between the highest and lowest points on a curve of cumulative degree-days versus time for one freezing season. It is used as a measure of the combined duration and magnitude of below-freezing temperatures occurring during any given freezing season. The index determined for air temperature approximately 4.5 feet above the ground is commonly designated as the air freezing index, while that determined for temperatures immediately below a surface is known as the surface freezing index.

(5) Design freezing index. The average air freezing index of the three coldest winters in the latest 30 years of record. If 30 years of record are not available, the air freezing index for the coldest winter in the latest 10-year period may be used.

(6) Mean freezing index. The freezing index determined on the basis of mean temperatures. The period of record over which temperatures are averaged is usually a minimum of 10 years, and

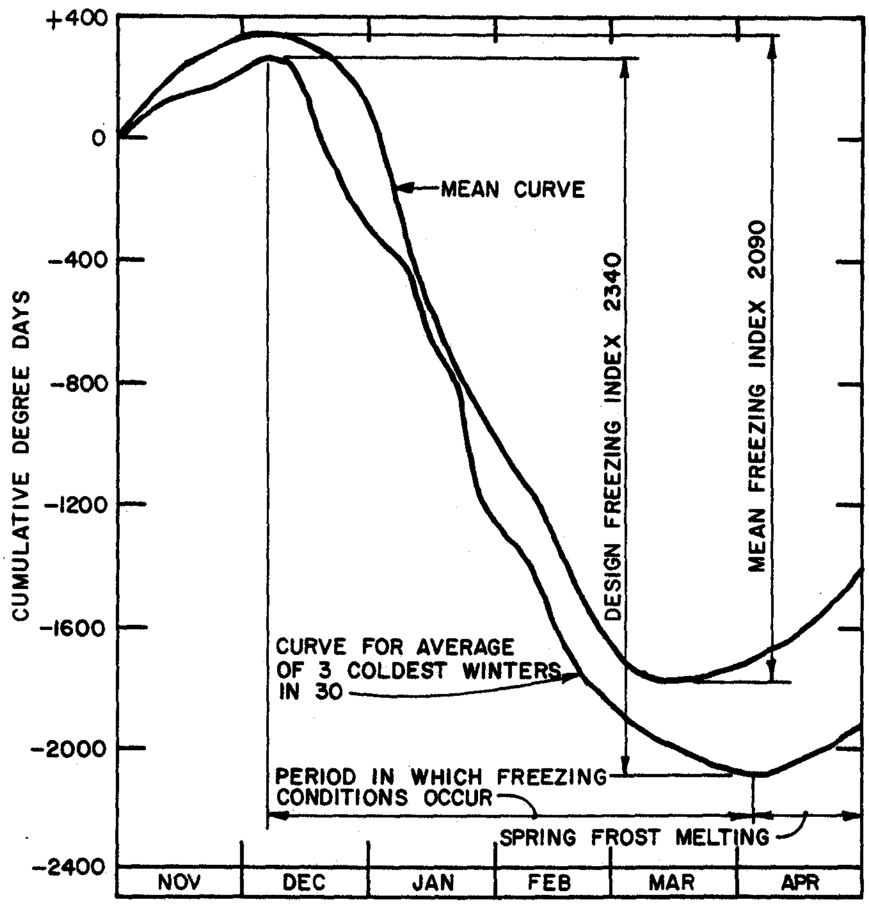

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FIGURE 1-1. DETERMINATION OF THE FREEZING INDEX preferably 30, and should be the latest available. The mean freezing index is illustrated in figure 1-1.